

L E S S O N 11

Traffic Calming

11.1 Purpose

Traffic calming is a traffic management approach that evolved in Europe and is now being implemented in many U.S. cities. The following definition is quoted from *An Illustrated Guide to Traffic Calming* by Hass Klau (1990):

“Traffic calming is a term that has emerged in Europe to describe a full range of methods to slow cars, but not necessarily ban them, as they move through commercial and residential neighborhoods. The benefit for pedestrians and bicyclists is that cars now drive at speeds that are safer and more compatible to walking and bicycling. There is, in fact, a kind of equilibrium among all of the uses of a street, so no one mode can dominate at the expense of another.”

This chapter explores the principle of traffic calming and provides a variety of studies, design details, and photographs of areas where traffic calming has been effectively used in the United States and in Europe. Along with the advantages of traffic calming, the text describes mistakes that practitioners have sometimes made in implementing traffic-calming techniques.

11.2 Traffic-Calming Objectives

The most fundamental traffic-calming goal is to reduce the speed of vehicular movement. With reduction of speed, the following objectives can be realized:

1. **Improved “feel” of the street.**
This objective calls for increased community involvement in and “ownership” of the street. If people feel more comfortable on the street, they are more likely to walk or bicycle there and to



engage in other street-oriented activities with their neighbors. A key aspect of achieving this objective is reducing the perceived threat of danger from motor traffic.

2. Enhanced aesthetic values and a sense of nature.

Several traffic-calming techniques, such as street landscaping, pedestrian amenities, and reclamation of roadway areas can serve as community open space. Not only do these techniques make the neighborhood more attractive, but they also break up long, uninterrupted street vistas conducive to speeding and convey the message that “this is a pedestrian place.”

3. Reduced crime.

It’s harder to make a speedy getaway if a fleeing felon has to deal with speed humps, woonerfs, and traffic circles. It’s harder to get away without being spotted if there are “eyes on the street” – if the street is a positive, community focus.

4. Equitable balance among transportation modes.

With reduced motorist speeds, safety is improved. Pedestrians and bicyclists have more time to detect and avoid motor vehicles. Traffic



Traffic-calming devices are used to break up long uninterrupted street vistas that encourage speeding.

calming sends the message that “motor vehicles don’t exclusively OWN the roadway” – that other modes have equal rights. Studies that evaluate traffic-calming improvements show increased levels of walking, bicycling, and transit use following installation.

5. Increased safety/decreased severity of injury in traffic crashes. With reduced speeds comes a significant reduction in the number and severity of crashes involving motor vehicles. Traffic-calming

facility evaluations uniformly show fewer crashes, fewer fatalities, and less severe injuries.

6. Improved air quality and noise levels.

Slower moving vehicles make less noise and, generally, emit fewer pollutants.

7. Decreased fuel consumption.

With more trips made by walking, bicycling, and transit, and with slower traffic speeds, fuel consumption reductions of 10 to 12 percent have been reported.

8. Continued accommodation of motor vehicle traffic.

An important objective is the continued accommodation of motor vehicle traffic. Although traffic calming shifts the balance among travel

modes, this shift should not result in severely restricted traffic volumes or in shifting traffic problems from the traffic-calmed area to other streets.



11.3 Traffic-Calming Issues

When any new traffic management approach is introduced, issues, concerns, and questions are bound to arise. Design decisions related to traffic can have far-reaching consequences. Lives, economic well-being, and urban livability are directly affected.

Professional engineers, planners, government, and the public all are aware of and sensitive to proposals for changes in the traffic environment. Roadway congestion, air quality, traffic safety, street crimes, and the high cost of new improvements are among the most-widely debated issues in America today. New design ideas are, and should be, subjected to rigorous testing and evaluation before being accepted as part of the standard engineering and transportation planning tool kit. Traffic calming is not a panacea for urban transportation woes, but it can have significant benefits in many situations.



Traffic calming can be termed as engineering and other physical measures designed to control traffic speeds and encourage driving behavior appropriate to the

In considering the application of traffic-calming techniques, what specific issues are likely to arise? The discussion on the following pages focuses on traffic-calming issues. (Note: Studies and statistics referenced are cited in FHWA Case Study Nos. 19 and 20, *National Bicycling and Walking Study*.)

1. Traffic safety.

The Issue: Encouraging people to walk, play, and bicycle in and next to the streets is just asking for trouble. They will have a false sense of security and accidents will increase. They will develop bad habits that may increase their when they leave the neighborhood.

Comment: Traffic-calming measures have been implemented in many European cities. In the Netherlands and Germany, extensive research has been conducted to evaluate the safety and impact of traffic-calming techniques and devices.

2. Impact on traffic volumes, distribution, and operations.

The Issue: Traffic calming will never work on anything except very low-volume residential streets. It will substantially reduce the amount of traffic that a street can handle efficiently and this is counterproductive. We need to move vehicles, not restrict them. Furthermore, if we slow traffic on one street, the traffic will simply be diverted to another street. The net result will be increased congestion and more problems overall.

Comment: A 5-year German Federal Government evaluation of traffic calming and follow-up research found:

- Little change in overall traffic volumes.
- Reduction in average vehicle speeds by almost 50 percent.
- Average increase in motorist trip time of only 33 seconds.

3. Lack of proven design standards.

The Issue: There are no uniform, accepted, and legally defensible standards to follow. If we want to try traffic calming, where can we get specific information about design?

Comment: Many U.S. cities are now developing and testing design guidelines for traffic-calming improvements. Although uniform, national standards have yet to evolve, valuable experience is being gained. The list of references at the end of this lesson provides a starting point for further exploration of specific design approaches.

4. Liability.

The Issue: These traffic-calming ideas may be accepted in Europe, but they haven't really been tried here. Are we opening the door to all kinds of legal problems if somebody crashes on a traffic circle or a speed table and sues us?

Comment: When considering the use of any new design approach, concerns about liability can be



Emergency vehicle access should always be considered when incorporating traffic-calming measures.

addressed somewhat through performance of “due diligence” on the part of the engineer, planner, or other professionals involved in the design. Research into the experiences of other U.S. cities, European standards, and evaluation studies should be thorough and followed up with a first-hand look if possible. Construction of a pilot project or other testing of proposed designs can benefit, as can ongoing and systematic evaluation of the improvements once installed.

5. Emergency and service vehicle access.

The Issue: Construction of speed bumps, neck-downs, medians, and traffic circles will increase response times for emergency vehicles and may restrict access for garbage trucks, delivery vans, and other large vehicles.

Comment: Studies in Berkley and Palo Alto, CA, show that traffic management measures (e.g., traffic diverters, bicycle boulevards) have not impaired police or fire emergency response times.

- The Seattle Engineering Department works closely with its Fire Department to design and field-test traffic circles on a site-specific basis to ensure good emergency access.

6. Impacts on bicycling.

The Issue: Pavement texturing, speed tables, wider sidewalks, “bulb-outs” at corners and similar improvements may make things better for pedestrians, but may have a negative impact on bicycling.

Comment: A 5-year German Federal Government evaluation of traffic calming and follow-up research found doubling of bicycle use over a 4-year period.

- Implementation of traffic management strategies in the downtown area of the Dutch City of Groningen contributed to a substantial increase in bicycling and walking. Bicycle use is now well over 50 percent of all trips.
- Studies of traffic-calming areas in Japan show increases in both bicycle and pedestrian traffic volumes along most routes.

(Note: *Cyclists and Traffic Calming*, a Technical Note publication of the Cyclists Touring Club (see references, end of lesson), includes extensive information on adapting traffic-calming techniques for bicycling.

11.4 Traffic-Calming Devices

Traffic calming has many potential applications, especially in residential neighborhoods and small commercial centers. Traffic-calming devices can be grouped within the following general categories:

- Bumps, humps, and other raised pavement areas.
- Reducing street area where motor traffic is given priority.
- Street closures.
- Traffic diversion.
- Surface texture and visual devices.
- Parking treatments.

Frequently, a combination of traffic-calming devices is used. Examples of such combinations will be discussed briefly, including:

- The woonerf.
- Entry treatments across intersections.
- Shared surfaces.
- Bicycle boulevards.
- Slow streets.

- Channelization changes.
- Traffic calming on a major road.
- Modified intersection design.

1. Bumps, humps, and other raised pavement areas.

This category includes all traffic-calming devices raised above pavement level. Drivers must slow down when they cross these devices or suffer an uncomfortable KER-BUMP or (KER-BUMP-KER-BUMP), running the risk of spilled coffee and a severe jolt to their tailbones. Although people often gripe about the inconvenience of having to slow down for these devices, they don't have much choice. Their effectiveness at slowing traffic cannot be disputed. They are sometimes referred to as "Silent Policemen."

Included in this category are:

- Speed bumps.
- Speed humps.
- Raised crosswalks.
- Raised intersections.

The following are brief descriptions of each, with definitions, comments, and examples:

Speed Bumps

A speed bump is a raised area in the roadway pavement surface extending transversely across the travel way, generally with a height of 3 to 6 inches and a length of 1 to 3 feet.

Design Considerations:

- Most effective if used in a series at 300- to 500- foot spacing.
- Typically used on private property for speed control – parking lots, apartment complexes, private streets, and driveways.
- Speed bumps are not conducive to bicycle travel, so they should be used carefully.



Speed bumps can be combined with curb extensions and a winding street alignment. Signing and pavement markings should clearly identify the bump.

Speed Humps

A speed hump (or "road hump") is a raised area in the roadway pavement surface extending transversely across the roadway. Speed humps normally have a minimum height of 3 to 4 inches and a travel length of approximately 12 feet, although these dimensions may vary. In some cases, the speed hump may raise the roadway surface to the height of the adjacent curb for a short distance.

The humps can be round or flat-topped. The flat-topped configuration is sometimes called a "speed table." Humps can

either extend the full width of the road, curb-to-curb, or be cut back at the sides to allow bicycles to pass and facilitate drainage.

Design Considerations:

- If mid-block pedestrian crossings exist or are planned, they can be coordinated with speed hump installation since vehicle speeds will be lowest at the hump to negotiate ramps or curbs between the sidewalk and the street.
- The hump must be visible at night.
- Speed humps should be located to avoid conflict with underground utility access to boxes, vaults, and sewers.



Speed humps slow traffic speeds on residential streets.

- Speed humps should not be constructed at driveway locations.
- Speed humps may be constructed on streets without curbs, but steps should be taken to prevent circumnavigation around the humps in these situations.
- Adequate signing and marking of each speed hump is essential to warn roadway users of the hump's presence and guide their subsequent movements.
- Speed humps should not be installed in street sections where transit vehicles must transition between the travel lane and curbside stop. To the extent possible, speed humps should be located to ensure that transit vehicles can traverse the hump perpendicularly.
- A single hump acts as only a point speed control. To reduce speeds along an extended section of street, a series of humps is usually needed. Typically, speed humps are spaced at between 300 and 600 feet apart.

Example:

Bellevue, Washington has installed speed humps in residential neighborhoods (labeled as speed “bumps” below, although broader than the typical speed bump). The City uses a 12-foot-wide hump, 3 inches high at the center. The design allows for little



Raised crosswalks can both slow motor traffic and give pedestrians a continuous-level surface at the crossing. Changes in texture and color help define the edges of the crossing.

or no discomfort at speeds of 15 to 25 mph, but will cause discomfort at higher speeds. The humps are marked clearly, distinguishing them from crosswalks. White reflectors enhance nighttime visibility.

Bellevue found that the speed humps reduced traffic speeds and volumes. The humps, in general, received strong public support, and residents favored their permanent installation.

The following concerns were raised regarding the speed hump installation:

- Concern about restricted access and increased response time for emergency vehicles. The Bellevue Fire Department asked that the humps be installed on primary emergency access routes.
- Concern about aesthetics of signing and markings at the traffic humps. Residents raising the concerns, however, felt that the speed reductions compensated for the appearance of the humps.
- Concern about the effectiveness of the humps in reducing motor vehicle speeds along the length of a street, not at just two or three points. The distance between speed humps was found to have an impact on traffic speeds. The City found that maximum spacing should be approximately 500 feet.

The Bellevue Department of Public Works concluded that speed humps were effective speed-control measures on residential streets and recommended their use be continued. The table on the following page summarizes “before” and “after” data related to the Bellevue speed humps:

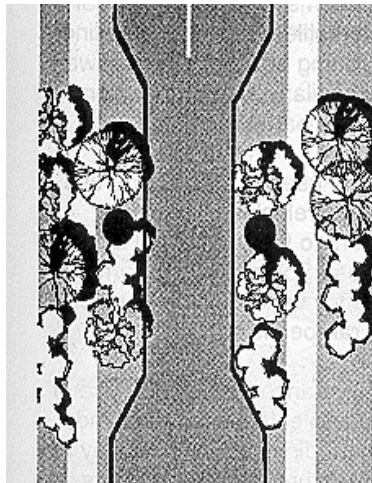
Raised Crosswalks

Raised crosswalks are essentially broad, flat-topped speed humps that coincide with pedestrian crosswalks at street intersections. The crosswalks are raised above the level of the roadway to slow traffic, enhance crosswalk visibility, and make the crossing easier for pedestrians who may have difficulty stepping up and down curbs.

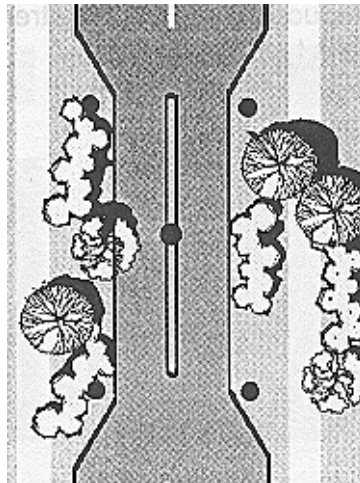
Table 2. Bellevue Speed Humps Findings

LOCATION	STREET TYPE/ WIDTH	# OF HUMPS	HUMP SPACING	SPEED LIMIT	Before:		After:	
					85TH % SPEED	VPD	85TH % SPEED	VPD
Somerset Drive SE	Two-way, 40 feet wide local residential neighborhood street	2	340'	25 mph	39 mph	795	27 mph	541 (VPD increased to 746 when the hump was reduced from 3/4" to 3")
Highland Drive SE	Two-way, 35 feet wide neighborhood collector	3	220'	25 mph	36 mph	1,700	25 mph	No change because no alternative route exists
166th/162nd Avenue SE	Two-way, 36 feet wide local residential street; walk to school route	2	600'	25 mph	37 mph	655	24 mph	.017
		2	580'	25 mph	37 mph	472	27 mph	.017
SE 63rd Street	Two-way, 35 feet wide local residential street temporarily serving as a connection between two minor arterials	2	1,000'	25 mph	36 mph	2,456	27 mph	2,802
		3	500'					
Yarrow Bay neighborhood	Primarily a neighborhood connector	2	400		39 mph	3,685	25 mph	2,931
						1,641		1,653

Source: FHWA Case Study No. 19.



ONE-LANE SLOW POINT



TWO-LANE SLOW POINT

Design Considerations:

- Ramps should not exceed a maximum gradient of 16 percent.
- Raised and/or textured surfaces can be used to alert drivers to the need for particular care.
- Distinctive surfacing helps reinforce the concept of a “calmed” area and thus plays a part in reducing vehicle speeds.
- Distinctive surfacing materials should be skid-resistant, particularly on inclines.

Design Considerations:

- Can be constructed of brick, concrete block, colored asphalt or cement, with ramps striped for better visibility.
- Raised crosswalks are applicable:
 - (1) On roadways with vehicular speeds perceived as being incompatible with the adjacent residential land uses.
 - (2) Where there is a significant number of pedestrian crossings.
 - (3) In conjunction with other traffic-calming devices, particularly entry treatments.
 - (4) On two-lane or fewer residential streets classified as either “local streets” or neighborhood collector streets.”
 - (5) On roadways with 85th percentile speeds less than 45 mph.

- Ramps should be clearly marked to enable bicyclists to identify and anticipate them, particularly under conditions of poor visibility.
- Care must be taken so the visually impaired have adequate cues to identify the roadway’s location (e.g., tactile strips). Color contrasts will aid those who are partially sighted.

2. Reducing street area where motor traffic is given priority.

This category of traffic-calming techniques includes all those that reduce the area of the street designated exclusively for motor vehicle travel. “Reclaimed” space is typically used for landscaping, pedestrian amenities, and parking.

Discussed here are:

- Slow points.
- Medians.
- Curb extensions.
- Corner radius treatment.
- Narrow traffic lanes.

Slow Points (neck-downs, traffic throttles, pinch points)

Slow points narrow a two-way road over a short distance, forcing motorists to slow and, in some cases, to merge into a single lane. Sometimes these are used in conjunction with a speed table and coincident with a pedestrian crossing. The following are advantages and disadvantages of both one-lane and two-lane slow points:

Intersection Humps/Raised Intersections

Intersection humps raise the roadway at the intersection, forming a type of “plateau” across the intersection, with a ramp on each approach. The plateau is at curb level and can be enhanced through the use of distinctive surfacing such as pavement coloring, brickwork, or other pavements. In some cases, the distinction between roadway and sidewalk surfaces is blurred. If this is done, physical obstructions such as bollards or planters should be considered, restricting the area to which motor vehicles have access.

(1) One-lane slow point.

One-lane slow points restrict traffic flow to one lane. This lane must accommodate motor traffic in both travel directions. Passage through the slow point can be either straight through or angled.

Advantages:

- Vehicle speed reduced.
- Most effective when used in a series.
- Imposes minimal inconvenience to local traffic.
- Pedestrians have a reduced crossing distance, greater safety.

Disadvantages:

- Reduced sight distances if landscaping is not low and trimmed.
- Contrary to driver expectations of unobstructed flow.
- Can be hazardous for drivers and bicyclists if not designed and maintained properly.
- Opposing drivers arriving simultaneously can create confrontation.

(2) Two-lane slow point.

Two-lane slow points narrow the roadway while providing one travel lane in each direction.

Advantages:

- Only a minor inconvenience to drivers.
- Regulates parking and protects parked vehicles as the narrowing can help stop illegal parking.
- Pedestrian crossing distances reduced.
- Space for landscaping provided.

Disadvantages:

- Not very effective in slowing vehicles or diverting through traffic.
- Only partially effective as a visual obstruction.

Design Considerations:

- Where slow points have been used in isolation as speed control measures, bicyclists have felt squeezed as motorists attempt to overtake them at the narrowing. Not all bicyclists have the confidence to position themselves in the middle of the

road to prevent overtaking on the approach to and passage through the narrow area.

- To reduce the risk of bicyclists' being squeezed, slow points should generally be used in conjunction with other speed control devices such as speed tables at the narrowing. Slower moving drivers will be more inclined to allow bicyclists through before trying to pass. Where bicycle flows are high, consideration should be given to a separate right-of-way for bicyclists past the narrow area.
- A textured surface such as brick or pavers may be used to emphasize pedestrian crossing movement. Substituting this for the normal roadway surface material may also help to impress upon motorists that lower speeds are intended.
- Such measures should not confuse pedestrians with respect to the boundary of the roadway area over which due care should still be taken. In particular, where a road is raised to the level of the adjacent sidewalk, this can cause problems for those with poor sight. However, a tactile strip may help blind people in distinguishing between the roadway and the sidewalk; similarly, a color variation will aid those who are partially sighted.
- Slow points can be used to discourage use of the street by large vehicles. They can, however, be barriers to fire trucks and other emergency



This traffic-calming measure uses a landscaped median to narrow the travel lanes.

vehicles. Some designs permit access by emergency vehicles by means of lockable posts or ramped islands.

- Slow points can enhance the appearance of the street. For example, landscaped islands can be installed, intruding into the roadway to form a narrow “gate” through which drivers must pass. Landscaping enhances the neighborhood’s sense of nature and provides a visual break in views along the street.



This median provides a diagonal waiting area for bicyclists, including a railing to hold onto.

- Slow points are generally only sanctioned where traffic flows are less than 4,000 to 5,000 vehicles per day. Above this level, considerable delays will occur during peak periods.
- Clear signing should indicate traffic flow priorities.

Slow Point Examples:

Medians

Medians are islands located along the roadway centerline, separating opposing directions of traffic movement. They can be either raised or flush with the level of the roadway surface. They can be expressed as painted pavement markings, raised concrete platforms, landscaped areas, or any of a variety of other design forms. Medians can provide special facilities to accommodate pedestrians and bicyclists, especially at crossings of major roadways.

Design Considerations:

- Medians are most valuable on major, multi-lane roads that present safety problems for bicyclists and pedestrians wishing to cross. The minimum central refuge width for safe use by those with wheelchairs, bicycles, baby buggies, etc. is 1.6 meters (2 meters is desirable).
- Where medians are used as pedestrian and bicyclist refuges, internally illuminated bollards are suggested on the medians to facilitate quick and easy identification.

- Used in isolation, roadway medians do not have a significant impact in reducing vehicle speeds. For the purpose of slowing traffic, medians are generally used in conjunction with other devices, such as curb extensions or roadway lane narrowing.

Several caveats apply:

- To achieve meaningful speed reductions, the travel lane width reduction must be substantial and visually obvious. The slowing, however, is temporary; as soon as the roadway widens again, traffic resumes its normal speed.

- Bicyclists have been put at risk of being squeezed where insufficient room has been left between a central median and the adjacent curb. Experience shows that most drivers are unlikely to hold back in such instances to let bicyclists go through first. This threat is particularly serious on roads with high proportions of heavy vehicles.
- The contradiction between the need to reduce the roadway width sufficiently to lower motorist speeds, while at the same time leaving enough room for bicyclists to ride safely, must be addressed. This may be achieved by reducing the roadway width to the minimum necessary for a bicyclist and a motorist to pass safely (i.e., 3.5 meters).

There are three suggestions:

- Introducing color or texture changes to the road surface material around the refuge area reminds motorist that a speed reduction is intended.
- White striping gives a visual impression that vehicles are confined to a narrower roadway than that created by the physical obstruction — adjacent areas exist that vehicles can run over, but these are not generally apparent to approaching drivers.
- In some cases, provide an alternate, cut-through route for the bicyclists.

Curb Extensions

The sidewalk and/or landscaped area on one or both sides of the road is extended to reduce the roadway to a single lane or minimum-width double lane. By reducing crossing distances, sidewalk widening is used to facilitate easier and safer pedestrian movement.

Reducing roadway width results in vehicle speed reductions. When curb extensions are used at intersections, the resultant tightened radii ensure that vehicles negotiating the intersection do so at slow speeds.

Design Considerations:

- Can be installed either at intersections or mid-block.
- May be used in conjunction with other traffic-calming devices.
- Curb extensions are limited only to the degree that they extend into the travelway. Curb extensions cannot impede or restrict the operation of the roadway.
- Successful bicycle facilities need a clear separation from sidewalk and street pavement, with adequate distances from parked cars to avoid opening doors. Cross-traffic should be slowed to allow bicyclists better continuity and safety.
- Narrowing certain streets can, at the same time, create safer bicycle facilities, but care should be taken that bicyclists are not squeezed by overtaking vehicles where the road narrows. Encouraging motorists to let the bicyclists through first by using complementary traffic-calming techniques such as speed tables and cautionary signing or leaving sufficient room for both to pass safely at the narrowing would be appropriate measures.
- If it is expected that a motorist should be able to pass a bicyclist, the minimum desirable width is 3.5 meters.



A 7-foot radius allows for a slow and safe turn. As the radius increases, so does the speed of the vehicle.

- Curb extensions can be employed to facilitate bicycle movement where a segregated multi-use trail crosses a busy street.

Corner Radius Treatment

Corner radii of intersection curbs are reduced, forcing turning vehicles to slow down. Efforts to accommodate trucks and other large vehicles have historically led to increased corner radii at intersections.

The following results have been observed:

- Large vehicles (trucks, vans, etc.) turn the corners easily.
- Other vehicles turn faster than with a reduced radius corner.
- Pedestrian crossing distances are increased by up to 4 feet, depending on the radius.
- Pedestrian safety is decreased, due to higher speeds.
- The sharper turns that result from the reduced radii require motorists to reduce speed, increasing the time available to detect and take appropriate actions related to pedestrians at the crossing.

Advantage:

- Can result in increased safety for pedestrians by reducing crossing distances and slowing the speed of turning vehicles.

Disadvantages:

- May result in wide swings in turning movements of large vehicles.



The design of street closures should provide specific parking areas to discourage obstruction of bicycle and pedestrian traffic.

- May affect response times for emergency vehicles.

Design Consideration:

- To slow traffic, a corner radius of approximately 7 feet is recommended.

Narrow Traffic Lanes

Especially in residential areas, wide streets may not be necessary or desirable. Wide traffic lanes encourage faster motor vehicle speeds. Consideration should be given to the review of cross-sections for all street classifications to determine whether roadway lane widths can be reduced (within AASHTO guidelines) so more area can be dedicated to bicycle and pedestrian use and associated traffic-calming facilities.

Advantages:

- Additional area for landscaping, and pedestrian facilities.
- Reduced vehicle speeds and increased safety.

Disadvantage:

- On-street parking may be restricted.

Design Consideration:

- Cross-section approaching the reduced-width street should also be slowed.

Example: City of Portland, Skinny Street Program

The City of Portland requires most newly constructed residential streets to be 20 or 26 feet wide, depending

on neighborhood on-street parking needs. In the past, residential streets were required to be as wide as 32 feet. To achieve a variety of benefits, the City reduced residential street widths. The City's Fire Bureau participated in the development of this standard to ensure access for emergency vehicles.

3. Street closures.

Three types of street closures are described in the following discussion:

- Complete street closures.
- Partial street closures.
- Driveway links.

(Caution: Street closures must be considered in an area-wide context or traffic problems may simply shift to another nearby street).

Complete Street Closures

Street closures, generally on residential streets, can prohibit through-traffic movement or prevent undesirable turns. Street closures may be appropriate where large volumes of through-traffic or "short-cut" maneuvers create unsafe conditions in a residential environment.

Design Considerations:

- Where proposals are likely to lead to a reduction in access, prior consultation with residents at early stages of planning and design is especially important to minimize opposition.
- The benefits of exempting bicyclists should be carefully considered in all cases.
- Bicycle gaps should be designed to minimize the risk of obstruction by parked vehicles. Painting a bicycle symbol and other directional markings on the road in front of the bicycle gap has proven to be effective.
- Bollards can reduce the parking obstruction.
- Bollards should be lighted or reflectorized to be visible at night.

- The design of bicycle gaps should permit good visibility of adjacent roads.
- Signing should acknowledge the continued route as a through one for bicyclists.
- Clearly defined parking can reduce the problem of parked cars blocking the closure and bicycle gap.
- Police and fire departments should be consulted early in the design process to determine emergency access requirements. Often, removable bollards, crash gates, and card or key-operated gates can satisfy these requirements, combined with parking restrictions. A 20-foot-wide clear path is needed for emergency access.
- Tree planting, benches, and textured paving can enhance appearance.
- Street closures are recommended only after full consideration of all expected turning and reversing movements, including those of refuse trucks, fire trucks, and other large vehicles.

Partial Street Closures

Access to or from a street is prohibited at one end, with a no-entry sign and barrier restricting traffic in one direction. The street remains two-way, but access from the closed end is permitted only for bicyclists and pedestrians.

Design Considerations:

- Bicycle and pedestrian exemptions should be provided as a general rule, designed to minimize the likelihood of obstruction by parked vehicles.
- All signing should acknowledge the continued existence of the route as a through one for bicyclists and pedestrians.

Driveway Links

A driveway link is a partial street closure, where the street character is significantly changed so it appears to be a private drive. Typically, the

roadway is narrowed and defined with textured or colored paving. A ribbon curb or landscaping may be used to delineate roadway edges. “Reclaimed” roadway area is converted to pedestrian facilities and landscaping.

This is a very effective method of changing the initial impression of the street. If done right, drivers will not be able to see through. It appears as a road closure, yet allows through traffic.

The driveway link can provide access to small groups of homes and is especially applicable to planned residential developments. The “go slow” feel of the driveway link is enhanced by design standards that eliminate vertical curb and gutter and use a relatively narrow driveway cross-section. A ribbon curb may be used to protect roadway edges.

4. Traffic diversion.

Traffic diversion is one of the most widely applied traffic-calming concepts. It includes all devices that cause motor vehicles to slow and change direction to travel around a physical barrier. Physical barriers used to divert traffic in this fashion can range from traffic circles to trees planted in the middle of the road. The discussion that follows provides information on: traffic diverters, traffic circles, chicanes, and “tortuous” street alignments as traffic-calming devices.

Traffic Diverters

Traffic diverters are physical barriers installed at intersections that restrict motor vehicle movements in



Diagonal road closures/diverters limit vehicular access, but allow emergency vehicles to enter through removable bollards.

selected directions. The diverters may be designed to prevent right- or left-hand turns, to block straight-ahead travel and force turns to the right or left, or create a “T” intersection. In all cases, paths, cut-throughs, or other provisions should be made to allow bicyclists and pedestrians access across the closure.

Traffic diverters can take many forms. Here are two examples:

(1) Diagonal road closure/diversion.

Straight-through traffic movements are prohibited. Motorists are diverted in one direction only.

Advantages:

- Through-traffic is eliminated.



The splitter islands should be raised and landscaped to prevent left-turning vehicles from taking a short cut to avoid driving around the outside of the island.

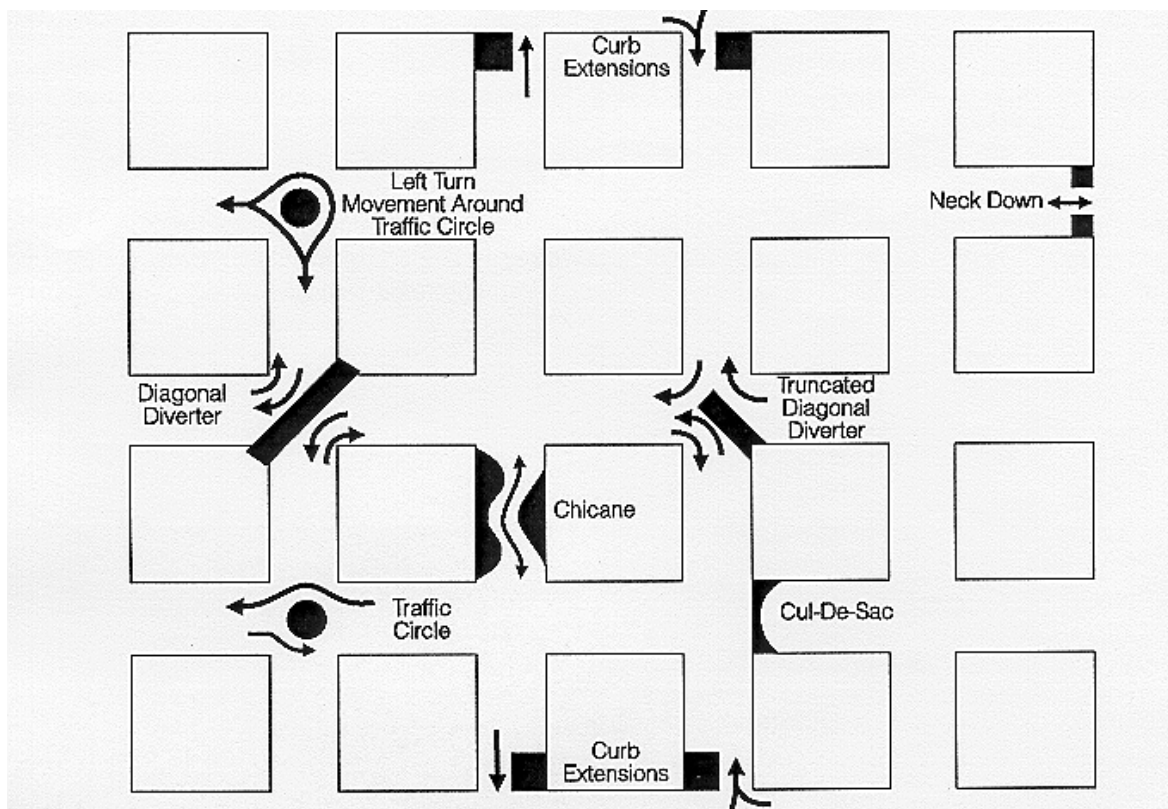
- Area for landscaping is provided.
- Conflicts are reduced.
- Pedestrian safety is increased.
- Can include a bicycle pathway connection.

Disadvantages:

- Will inconvenience residents in gaining access to their properties.
- May inhibit access by emergency vehicles unless street names are changed.
- Will move through traffic to other streets if not back to the arterial.

Example:

Eugene, Oregon has used diagonal diverters with positive community response. Eugene installs the



Example of an integrated traffic-calming plan.

diverters on a temporary basis to get neighborhood feedback before making a permanent installation. Two types of diagonal diverters are used — some are landscaped, while others are just guardrails. Both types have openings for bicycles. These have been supported by nearby residents.

Seattle installed truncated diagonal diverters, which allow right-turn movements around one end of the diverter. The Engineering Department found that these diverters were disruptive to neighborhood traffic and has focused instead on installation of traffic circles to control neighborhood traffic problems. Problems experienced with diverters included: (1) travel time and distance increased for all users; (2) local residents were diverted to other streets; (3) visitors and delivery services were often confused and delayed; and (4) emergency vehicle response times were potentially increased.

(2) Turning-movement diverters.

This type of diverter is designed to prevent cut-through traffic at the intersection of a neighborhood street with a major street or collector. It prevents straight-through movements and allows right turns only into and out of the neighborhood.

Advantages:

- Effective at discouraging cut-through traffic.
- Relatively low cost.
- Creates sense of neighborhood entry and identity.

Disadvantages:

- Limits resident access. Should be installed as part of overall neighborhood circulation improvements to ensure reasonable convenience for residents.
- Motorists may try to override the diverter to make prohibited turns unless vertical curbs, barriers, landscaping, or other means are used to discourage such actions.



Traffic circles can be designed to accommodate large vehicles and emergency access without undue restrictions.

Traffic Circles

Small traffic circles (center island approximately 4 meters in diameter) can be used as traffic-calming devices at intersections, reducing vehicle speeds. A roundabout is a channelized intersection at which all traffic moves counterclockwise around a central traffic island. These islands may be painted or domed, mountable elements may be curbed, and may include landscaping or other improvements.

Advantages:

- Crashes reduced by 50 to 90 percent when compared to two-way and four-way stop signs and other traffic signs by reducing the number of conflict points at intersections.
- Effective in reducing motor vehicle speeds. Success, however, depends on the central island being sufficiently visible and the approach lanes engineered to deflect vehicles, preventing overrun of the island. Overrunnable roundabouts on straight roads are less likely to produce the desired speed reduction.

Roundabout Accident Study

In 1989, a survey of crashes at mini-roundabouts examined years of crash data for 447 sites in England, Wales, and Scotland.

Key survey findings were:

- Mini-roundabouts were most commonly used on streets with speed limits of 30 mph or less.



Where possible, cyclists should be provided with cycle slips which enable them to bypass speed humps.

- Mini-roundabouts were found to have a far lower overall accident rate than that of signalized intersections with equivalent speed limits.
- Looking only at crashes involving bicycles, the study showed that four-arm mini-roundabouts have about the same involvement rate (accidents per million vehicles of that type entering the intersection) as do conventional, four-legged, signalized intersections.

Comparative Accident Rates:

Signalized intersections:

2.65 accidents/intersection/year
34 accidents per 100 million vehicles
20% resulted in serious or fatal injury

Roundabouts:

0.83 accidents/intersection/year
20 accidents per 100 million vehicles
19% resulted in serious or fatal injury

Both types of intersections compared have 30-mph speed limits and are four-legged intersections.

Splitter islands are the islands placed within a leg of the roundabout, separating entering and exiting traffic and designed to deflect entering traffic. They are designed to prevent hazardous, wrong-way turning movements.

These islands are important design elements and should be provided as a matter of routine, wherever feasible. Without splitter islands, left-turning

motorists have a tendency to shortcut the turn to avoid driving around the outside of the central island. The islands should, preferably, be raised and landscaped. If this is not possible, painted island markings should be provided.

Design Considerations:

- Roundabouts should preferably have sufficiently raised and highly visible centers to ensure that motorists use them, rather than overrunning.
- Clear signing is essential.

- Complementary speed reduction measures such as road humps on the approach to roundabouts can improve safety.
- The design of roundabouts must ensure that bicyclists are not squeezed by other vehicles negotiating the feature. Yet, where possible, adequate deflection must be incorporated on each approach to enforce appropriate entry speeds for motor vehicles.

Example: Seattle Neighborhood Traffic Control Program

The Seattle Engineering Department (SED) has experimented since the 1960's with a variety of neighborhood traffic control devices. The major emphasis of the SED Neighborhood Traffic Control Program is installing traffic circles (roundabouts) at residential street intersections. City staff report that about 30 circles are built each year. A total of approximately 400 circles have been installed to date. Each circle costs about \$5,000 to \$6,000.

In Seattle, a traffic circle is an island built in the middle of a residential street intersection. Each circle is custom-fitted to the intersection's geometry; every circle is designed to allow a single-unit truck to maneuver around the circle without running over it. A 2-foot concrete apron is built around the outside edge of the circle to accommodate larger trucks. Large trucks, when maneuvering around the circle, may run over the apron. The interior section of the circle is usually landscaped.

SED coordinates the design and construction of each circle with the Seattle Fire Department and school bus companies.

Traffic circles are installed at the request of citizens and community groups. Because there are more requests than funding to build them, SED has created a system for evaluating and ranking the requests. Before a request can be evaluated, a petition requesting a circle must be signed by 60 percent of the residents within a one-block radius of the proposed location. Then, the intersection's collision history, traffic volume, and speeds are studied.

Chicanes

Chicanes are barriers placed in the street that require drivers to slow down and drive around them. The barriers may take the form of landscaping, street furniture, parking bays, curb extensions, or other devices.

The Seattle Engineering Department has experimented with chicanes for neighborhood traffic control. It has found chicanes to be an effective means of reducing speed and traffic volumes at specific locations under certain circumstances. A demonstration project at two sets of chicanes showed:

- Reduction of traffic volumes on the demonstration streets.
- Little increase in traffic on adjacent residential streets.
- Reduced motor speeds and collisions.
- Strong support for permanent installation of chicanes by residents (68 percent).

Design Considerations:

- Consideration should be given to safe bicycle travel. Bicycle bypasses and signs to indicate directional priority are suggested.
- A reduction in sight lines should not be used in isolation to reduce speeds, as alone, this could be

potentially dangerous. A reduction in sight lines may be appropriate to avoid excessive land taking or as a reinforcing measure only where other physical features are employed that reduce speed.

- Chicanes offer a good opportunity to make environmental improvements through planting. However, preference should be given to low-lying or slow-growing shrubs to minimize maintenance and ensure good visibility.
- Measures should be employed to ensure that chicanes are clearly visible at night.
- Where full closure or speed humps are not feasible, chicanes may be used to reduce traffic speeds. Many different layouts are possible, including staggered parking (on alternating sides of the road).

Tortuous Roads

Roads can be designed to meander or jog sharply, slowing traffic and limiting views to discourage speeding. This technique can incorporate use of cul-de-sacs and courtyards.

Design Considerations:

Tortuous roads are generally planned as part of the design stage of a new road layout, rather than being superimposed on an existing layout. The siting of buildings is used to create a meandering road.



These pavement markings at a median refuge not only delineate the crossing for motorists, but also cue pedestrians about the location of the roadway edge.

- Designers should be aware of the need for accessibility to residential properties, both in terms of servicing and the needs of the individual. Tortuous roads will prove to be unpopular if they severely restrict accessibility.
- Where traffic is deliberately diverted onto a tortuous route — to avert town center congestion, for example — consideration should be given to maintaining as direct a route as possible for bicyclists.
- Tortuous roads (a.k.a. serpentine) are under study, but have not yet been approved for use in Portland. If approved, they would be limited for use on two-lane or fewer residential streets.
- Road design is limited by AASHTO standards for transition taper lengths.
- This traffic-calming device may require significant parking removal and should be used where parking removal is not an issue.

5. Surface texture and visual devices.

This category of traffic-calming devices includes signing, pavement marking, colored and textured pavement treatments, and rumble strips. These devices provide visual and audible cues about the traffic-calmed area. Colors and textures that contrast with those prevailing along the roadway alert

motorists to the need for alertness, much as conspicuous materials increase bicyclist and pedestrian visibility. Signs and pavement markings also provide information about applicable regulations, warnings, and directions.

Signing and Pavement Markings

Installation of directional, warning, and informational signs and pavement markings should conform to MUTCD guidelines, as applicable. Traffic-calming devices may be new to many people in the United States and the signs and markings will help minimize confusion and traffic conflicts.

Design Considerations:

- A part of the sign/pavement marking approach to mitigating traffic in residential areas includes painting of stripes/lines on the roadway and other patterns that are designed to have a psychological impact on drivers. Although such patterns are basically intended to slow vehicles rather than reduce traffic, they should make passage over residential streets less desirable than if the roadway were untreated, in effect, encouraging the use of alternative routes.
- Many of the patterns tried have had only marginal success. In a few cases, the average speed increased slightly. A pattern that is successful is that of painting transverse bands.

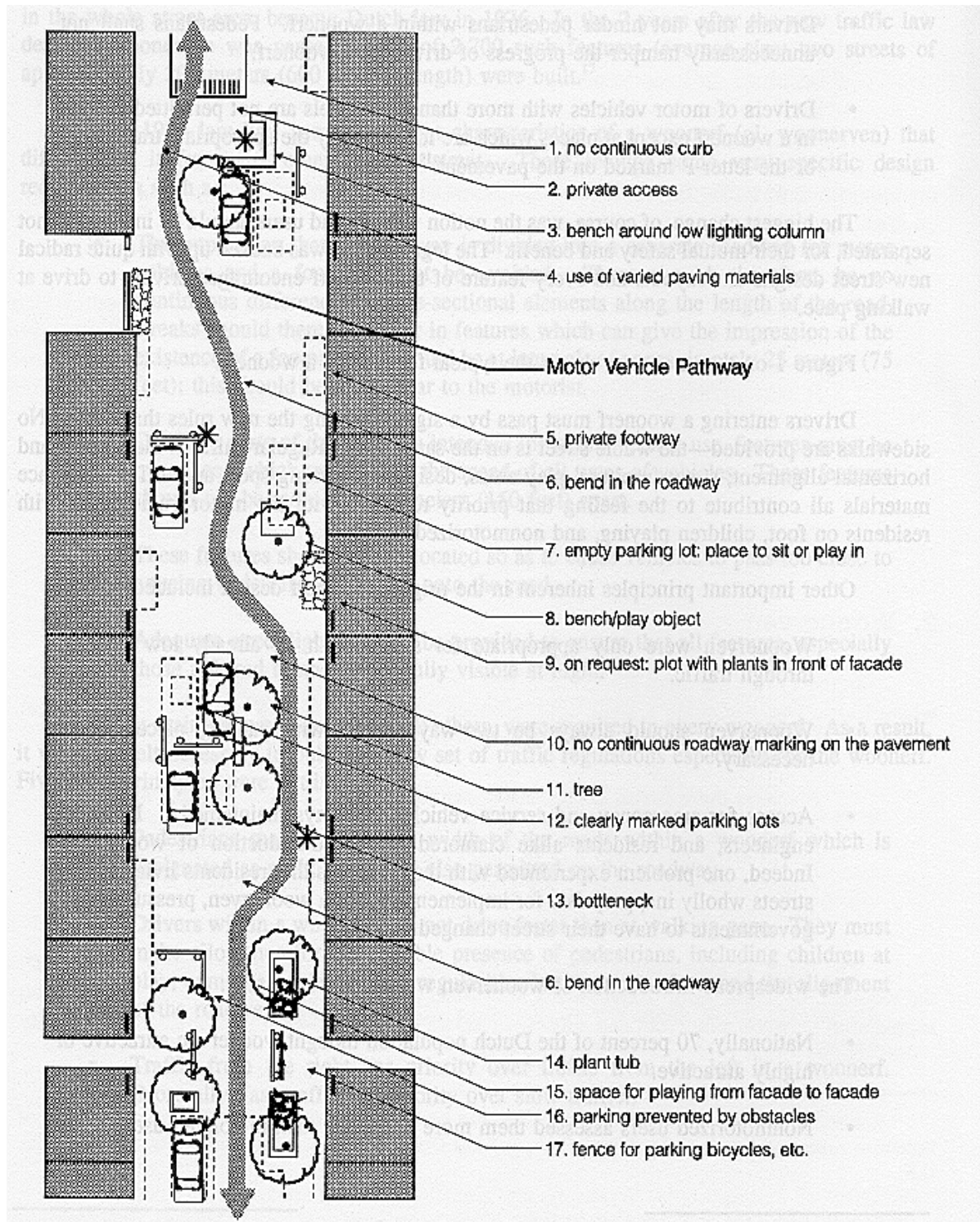
Painted lines are applied to the road at decreasing intervals approaching an intersection or “slow-down” point. They are intended to give the impression of increasing speed and motorists react by slowing down.

Pavement Texturing and Coloring

The use of paving materials such as brick, cobbles, concrete pavers, or other materials that create variation in color and texture reinforces the identity of the area as a traffic-restricted zone.



Pavement treatments can be applied to the entire traffic-calmed area or limited to specific street uses. The texture or color should be a noticeable contrast to the approaching roadways if speeds are to be reduced.



Model of a "woonerf."



The distinction between sidewalks and roadway is blurred in woonerfs.

1. The woonerf.

A woonerf (or “living yard”) combines many of the traffic-calming devices just discussed to create a street where pedestrians have priority and the line between “motor vehicle space” and “pedestrian (or living) space” is deliberately blurred (see the model of a woonerf). The street is designed so motorists are forced to slow down and exercise caution. Drivers, the Dutch say, do not obey speed limit signs, but they do respect the design of the street.

Design Considerations:

- The choice of materials should ensure that they do not pose a danger or deterrent to bicyclists. Cobbles present special difficulties, particularly for vehicles with narrow wheels and without the benefit of suspension. Such treatment is particularly discouraging for bicyclists on steep slopes, making it harder to maintain momentum when riding uphill. Thus, as a general rule, cobbles should not be employed. Similarly, pavers with chamfered edges impair a bicyclist’s stability and should be avoided.
- The color and texture of the street surface are important aspects of the attractiveness of many residential streets. The variation from asphalt or concrete paving associated by most people with “automobile territory” signals to the motorist that he or she has crossed into a different, residential zone where pedestrians and bicyclists can be expected to have greater priority.

Putting the Design Techniques to Work: Selected Examples of Traffic Calming

Most traffic-calmed streets utilize a combination of the devices just discussed. The following are some examples: the woonerf, entry treatments, shared streets, and other techniques (bicycle boulevards, modified street design, modified intersection design, channelization changes, traffic calming on a major road, slow streets, transit streets, and pedestrian zones).

The woonerf (plural — woonerven) is a concept that emerged in the 1970’s as increased emphasis was given by planners to residential neighborhoods. People recognized that many residential streets were unsafe and unattractive and that the streets, which took up a considerable amount of land area, were used for nothing but motor vehicle access and parking. Most of the time, the streets were empty, creating a “no-man’s land” separating the homes from one another.

The Dutch, in particular, experimented extensively with street design concepts in which there was no segregation between motorized and non-motorized traffic and in which pedestrians had priority.

A law passed in 1976 provided 14 strict “design rules” for woonerven and resulted in construction of 2,700 such features in the following seven years.

The woonerven were closely evaluated, with the following findings:

- Injury accidents were reduced by 50 percent.
- Vehicle speeds were reduced to an average of 8 to 15 mph (13 to 25 km/h).
- Nationally, 70 percent of the Dutch population thought woonerven to be attractive or highly attractive.
- Non-motorized users assessed woonerven more positively than motorized users.

- Feedback from residents living on woonerfs was very positive. They appreciated the low traffic volumes and absence of cut-through traffic, but considered the larger play areas and other improvements to the street environment to be even more important benefits.

Woonerf Design Principles:

Following evaluation of the woonerven, the Dutch law was amended (July 1988) to allow greater design flexibility, replacing the design rules with six basic principles.

- (1) The main function of the woonerf shall be for residential purposes. Thus, roads within the “erf” area may only be geared to traffic terminating or originating from it. The intensity of traffic should not conflict with the character of the woonerf in practical terms: conditions should be optimal for walking, playing, shopping, etc. Motorists are guests. Within woonerven, traffic flows below 100 vehicles per hour should be maintained.
- (2) To slow traffic, the nature and condition of the roads and road segment must stress the need to drive slowly. Particular speed-reduction features are no longer mandated, so planners can utilize the most effective and appropriate facilities.
- (3) The entrances and exits of woonerven shall be recognizable as such from their construction. They may be located at an intersection with a major road (preferable) or at least 20 meters (60 feet) from such an intersection.
- (4) The impression shall not be created that the road is divided into a roadway and sidewalk. Therefore, there shall be no continuous height differences in the cross-section of a road within a woonerf. Provided this condition is met, a facility for pedestrians may be realized.

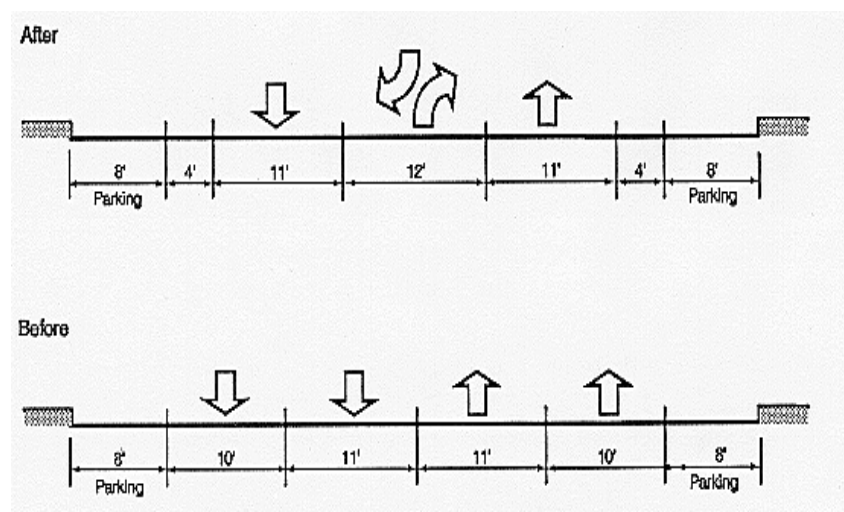
Thus, space can be designated for pedestrians and a measure of protection offered, for example, by use of bollards or trees.

- (5) The area of the road surface intended for parking one or more vehicles shall be marked at least at the corners. The marking and the letter “P” shall be clearly distinguishable from the rest of the road surface. In shopping street “erfs” (winkelerven), special loading spaces can be provided, as can short-term parking with time limits.
- (6) Informational signs may be placed under the international “erf” traffic sign to denote which type of “erf” is present.

2. Entry treatment across intersections.

Traffic-calming devices can be combined to provide an entry or “gateway” into a neighborhood or other district, reducing speed through both physical and psychological means. Surface alterations at intersections with local streets can include textured paving; pavement inserts; or concrete, brick, or stone materials. At the entry, the surface treatment can be raised as high as the level of the adjoining curb. Visual and tactile cues let people know that they are entering an area where motor vehicles are restricted.

Eugene, Oregon installs curb extensions at entrances to neighborhood areas, usually where a residential



The conversion of a 58-foot roadway. Elimination of one travel lane in each direction creates space for bicyclists.

street intersects an arterial. The curb extension is placed to prevent motor vehicle traffic from cutting through the neighborhood. The curb extension is signed as a neighborhood entrance or exit. Most of the street remains two-way, but one end becomes a one-way street. Compliance by motor vehicles is mostly good. Bikes are allowed to travel both ways at all curb extensions.

3. Bicycle boulevards.

The City of Palo Alto, California has moved beyond spot traffic-calming treatments and has created bicycle boulevards — streets on which bicycles have priority.

The purpose of a bicycle boulevard is to provide:

- Throughway where bicycle movements have precedence over automobiles.
- Direct route that reduces travel time for bicyclists.
- Safe travel route that reduces conflicts between bicyclists and motor vehicles.
- Facility that promotes and facilitates the use of bicycles as an alternative transportation mode for all purposes of travel.

The Palo Alto bicycle boulevard is a 2-mile stretch of Bryant Street — a residential street that runs parallel to a busy collector arterial. It was created in 1982 when barriers were fitted to restrict or prohibit through motor vehicle traffic, but to allow through bicycle traffic. In addition, a number of stop signs along the boulevard were removed. An evaluation after 6 months showed a reduction in the amount of motor vehicle traffic, a nearly twofold increase in bicycle traffic, and a slight reduction in bicycle traffic on nearby streets.

The City also found that anticipated problems failed to materialize and concluded that a predominately stop-free bikeway — on less traveled residential streets — can be an attractive and effective route for bicyclists. The bicycle boulevard bike traffic increased to amounts similar to those found on other established bike routes.

The bicycle boulevard continues to function as a normal local city street, providing access to residences, on-street parking, and unrestricted local

travel. The City received complaints about the visual appearance of the initial street closure barriers (since upgraded with landscaping), but is unaware of any other serious concerns of nearby residents.

Plans for the extension of the bicycle boulevard through downtown Palo Alto were approved by the City Council in the summer of 1992. Included in this extension was the installation of a traffic signal to help bicyclists cross a busy arterial.

4. Channelization changes.

The Seattle Engineering Department is changing some of its streets from four lanes to two lanes, with a center left-turn lane. These channelization changes can provide extra room for bicycle lanes or a wide lane for cars and bikes to share.

Numerous comments from users of some of those streets say motor vehicle speeds seem to have decreased. One street in particular, Dexter Avenue North, is a popular commuting route to downtown Seattle for bicyclists.

Traffic counts on the street show bicyclists make up about 10 to 15 percent of the traffic at certain times during the day. The rechannelization had little or no effect on capacity, reduced overtaking accidents, and made it easier for pedestrians to cross the street (by providing a refuge in the center of the road).

11.5 Exercise

Do one of the following exercises:

1. Choose a site-specific location (such as two to three blocks of a local street) where fast traffic or short cuts are a problem. Conduct a site analysis to determine problems. Prepare a detailed site solution that incorporates several traffic-calming devices. Illustrate with drawings and describe the anticipated changes in traffic speed.
2. Prepare a traffic-calming solution for an entire neighborhood or downtown area that illustrates an area-wide approach to slowing traffic. Conduct a site analysis to determine problem areas. Illustrate your solutions and describe the anticipated changes in traffic speed and flow.

11.6 References

Text and graphics for this lesson were derived from the following sources:

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